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The Effects of Price Cap Regulation on Tobacco Market

by

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Biographic Note

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Abstract

The tobacco market has serious market failures that justify tobacco regulation. Besides being an addictive good with severe consequences for health, the worldwide tobacco industry is characterized by high concentration and consequently by the presence of market power exerted by tobacco manufacturers.

The intention of this work is to study the economic effects of an innovative method to regulate the tobacco market: price cap regulation applied to tobacco producers. Price cap regulation has already been applied in many sectors around the world. However it was never related to tobacco market until 2010. In this work, it is developed a theoretical model with two periods where an upstream firm, subject to price cap constraint, sells to the downstream firms. Additionally the strategic behavior of the upstream firm and the asymmetric costs between downstream firms is also object of study. The model shows the impact of price regulation, the upstream behavior and the asymmetric costs on the market variables. The results indicate that price cap regulation reduces producer's profits when this firm does not behave strategically and also that the consumers benefit from lower prices. However, if the tobacco retail price does not change, the government revenue will be increased and consumers only benefit from higher quantities. Regarding the cost asymmetry, a curious result is that it can be profitable for the upstream firm if there are asymmetric costs between his customers.

JEL codes: C72, L51, L66

Keywords: Tobacco Industry, Economic Regulation, Price Cap

Resumo

O mercado de tabaco tem sérias falhas de mercado que justificam a sua regulação. Para além de ser um bem aditivo, com consequências graves para a saúde, a indústria mundial do tabaco é caracterizada por ser altamente concentrada e, consequentemente, pela presença de poder de mercado exercido pelos produtores de tabaco.

O objectivo deste trabalho é estudar os efeitos económicos de um método inovador para regular o mercado do tabaco: regulação *price-cap* aplicada aos produtores de tabaco. Este tipo de regulação já tem sido aplicado em diversos sectores em todo mundo mas nunca foi relacionado ao mercado do tabaco até 2010. Neste trabalho é desenvolvido um modelo teórico com dois períodos onde uma empresa a montante, sujeita a restrição de preço, vende para as empresas a jusante. Adicionalmente, o comportamento estratégico da empresa a montante e a existência de custos assimétricos entre as empresas a jusante é também objecto de estudo. O modelo mostra o impacto da regulação de preços, do comportamento a montante e dos custos assimétricos nas variáveis de mercado. Os resultados indicam que este regime regulatório reduz os lucros do produtor quando este não se comporta de forma estratégica e também que os consumidores beneficiam de preços mais baixos. No entanto, se o preço de retalho não se alterar a receita fiscal aumentará e os consumidores apenas beneficiarão de mais quantidades disponíveis. No que diz respeito à assimetria de custos, um resultado curioso é que pode ser lucrativo para a empresa a montante se existirem custos assimétricos entre os seus clientes.

Códigos JEL: C72, L51, L66

Palavras-Chave: Indústria do Tabaco, Regulação Económica, *Price Cap*

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Chapter 1

Introduction

Economic regulation is necessary when there are market failures that significantly damage the market efficiency as it is the case of the tobacco industry. This market has obvious failures not only caused by externalities and lack of information but also due to the market power exercised by the so-called "Big Four" (Philip Morris International, British American Tobacco, Japan Tobacco and Imperial Tobacco) of the tobacco industry which together represent about 70% of world market share (Bialous and Peeters 2012). According to the fourth edition of The Tobacco Atlas[1], the profit's combination of the mentioned companies was 35 billion dollars in 2010 which corresponds to the combined profits of the Microsoft, Coca-Cola and Mc Donald's (Eriksen *et al.* 2012).

The tobacco industry is currently subject to several forms of regulation which try to achieve quite different objectives. The World Health Organization (WHO) divided those measures according two different aims: the reduction of the demand for tobacco and the reduction of the tobacco supply. In addition there are other policies to protect the environment (Nunes 2014). In order to reduce the demand the following measures, among others, can be applied:

- Price and tax measures (price and tax policies, prohibiting or restricting sales and imports by international travelers of tax and duty-free tobacco products).
- Ban tobacco smoking in indoor workplaces and public places (including public transports).
- Disclosure, to the Government and the public, information about contents and emissions of tobacco products (by manufacturers or importers of tobacco products).

[1] Document published in 2012 by the American Cancer Society and World Lung Foundation that includes all the statistical information about tobacco and tobacco industry.

- Regulation of the packaging and labeling of tobacco products (no advertising or promotion on packaging, health warnings describing the harmful effects of tobacco consumption, etc.)
- Educational and public awareness programmes.
- Ban all tobacco advertising, promotion and sponsorship.

In order to reduce the supply the following measures, among others, can be applied:

- Measures to reduce illicit trade in tobacco products (requiring the marking of all unit packets and packages of tobacco products, facilitating the information exchange between customs, tax and other authorities, strengthen legislation with penalties and remedies against illicit trade, etc.)
- Prohibition of sales of tobacco products to and by minors.

Nevertheless, tobacco was responsible for 6 million deaths worldwide in 2011 and in 2008 were produced 5.9 trillion cigarettes. In Portugal most of the measures mentioned above are actually in force. The strongest measure was instituted by Law No. 37/2007, of August 14, which entered into force on the 1st of January 2008. That law approves rules for citizens' protection from involuntary exposure to tobacco smoke and measures to reduce demand related to dependency and its consumption cessation, namely the prohibition of smoking in certain places and the sponsorship of any activities that directly or indirectly promote tobacco products. However, annual cigarette consumption was 1114 *per capita*, 17% of male deaths and 3.0% of female deaths are due to tobacco, in 2004. Additionally, the illicit cigarette market share was 6.3% (Eriksen *et al.* 2012).

Regarding the tobacco supply the policies are few, compared with policies to reduce the demand for tobacco, or are ineffective in reaching one of the major problems on tobacco manufacturers: the abnormal profits earned by the tobacco transnational companies. Thus, in the recent years, has raised the need for further action in this area. Gilmore *et al.* (2010) suggest an innovative way to regulate tobacco market that could reduce companies' profits, increase government revenue and also bring benefits for public health, goals very difficult to promote simultaneously. What they propose is the application of price cap regulation to tobacco manufacturers. This type of regulation was never related to tobacco market until the work of those authors. Therefore, this dissertation follow the suggestion of Gilmore *et al.* (2010) and focuses on the analysis of the effects of price cap regulation on tobacco market. The research questions can be synthesized by the following questions: “Does price cap regulation reduce producer’s profits?” and “How price cap regulation affects the government revenue and consumer welfare?” To answer those questions, we intend to model the idea of Gilmore *et al.* (2010) and thereby be able to evaluate the welfare on three different economic agents: producers, government and consumers. Thus, the methodology of the dissertation involves the construction of a theoretical model inspired by the Portuguese tobacco industry.

Price cap regulation was developed in United Kingdom in the 1980’s in the telecommunications industry (Armstrong *et al.* 1994). It consists in fixing a maximum price that companies can charge during a certain period of regulation, typically one year. This maximum price is equal to the price observed in the previous period adjusted by the inflation, the expected efficiency gains and eventually by exogenous costs not controlled by the firms. The expected efficiency gains are usually defined for a more largely period of regulation, typically between three and five years. It is known that the price cap system is used in many markets particularly in utilities but, as far as we know, it was never applied in the tobacco industry, whose main regulation instruments are the taxation of tobacco products and anti-smoking legislation, hence our interest and relevance in studying this topic. This is an unexplored topic that deserves to be studied taking into account the characteristics of the market and the product in question. The implementation of such a regime could be an important and relevant instrument in tobacco regulation.

This work is organized as follows: the literature review is presented on Chapter 2 and is divided in two different parts. The first part describes the literature already done about tobacco industry and the second part review the price cap regulation. On Chapter 3 is described the Portuguese tobacco industry, in particular the market structure on both production and distribution markets. Chapter 4 is dedicated to the model’s construction, where the hypothesis and variables are defined, the model is solved and all the results are discussed. Finally, on Chapter 5 are presented the final conclusions, which include the implications of the theoretical model and suggestions for future investigation.

Chapter 2

Literature Review

In this chapter it is presented a literature review about the market failures and the firm behavior linked to tobacco industry. It is also analyzed the effectiveness of tobacco control policies. Regarding the suggestion for a new regulation on tobacco market it is defined the price cap method, its application disadvantages and advantages against other types of regulation.

2.1. Tobacco Industry

The main topics in the economic literature about tobacco industry mainly discuss the demand for tobacco products (price-elasticity, income-elasticity, etc.) and the effectiveness of taxation (or other types of regulation) on variables such as consumption, price and welfare. Additionally, the literature also identifies, measures and analyzes the failures of tobacco market.

Therefore, a market failure that is intensively debated in the tobacco literature is the presence of market power and monopolistic behavior that could lead to abnormal profits on tobacco industry. Market power is defined as the ability of a firm to charge prices above marginal cost, affecting the quantity produced in the market and increasing their profits (Cabral 2000).

This capacity to set prices may be the result of the existence of high market concentration on tobacco industry. Thus, there are many works that studied the exercise of monopoly power, the majority applied on the U.S.A and using data on taxes (Sumner, 1981; Sullivan, 1985; Ashenfelter and Sullivan, 1987; Keeler *et al*, 1996). Although the perfect competition was rejected, it was considered that the effect of monopoly power as a cause for price variation was small compared with the tax rates or other costs. Sumner (1981) used data on annual tax rates and prices between 1954 and 1978, for 47 states and the District of Columbia, rejecting perfect competition but do not supporting the existence of cartel operations on tobacco industry. However, Sumner's work was subject to criticisms about the assumptions on demand. Then, in 1985, Sullivan (1985) try to establish the absence of a cartel using weaker assumptions in order to avoid those criticisms. He used data from 45 states between 1955 and 1982 and his results *"(...) point to at least a moderately high level of competition and, in particular, allow for the rejection of the perfect cartel model*". In turn, Ashenfelter and Sullivan (1987) used non parametric tests of the monopoly model on the same data as Sullivan (1985) to show that *"(...) monopoly hypothesis and other simple models that do not embody at least a moderate amount of competition serve as poor predictors of the effects of excise tax changes on cigarette prices, sales, and revenues."*, identical conclusions to Sullivan (1985). Contrarily to the previous works, they found that *"(...)excise tax increases do not consistently act to increase prices and decrease sales(...)"* what calls for other hypothesis for firm behavior. Keeler *et al.* (1996) found that cigarette manufacturers practice price discrimination by state, "*(...) though the effect is not large relative to the final retail price.*" Additionally, the authors conclude that the effects of each state taxes are more than proportional: *"(...) a 1 cent state tax increase results in a price increase of 1.11cents (...)*" (contrarily to Ashenfelter and Sullivan (1987) where tax increases were not consistent with price increases). Moreover they find that the effects of local anti-smoking regulations may be offset by sellers through a retail price reduction to deal with possible demand declines.

Later, other authors began to study the case of bilateral market power between cigarettes manufacturers and leaf tobacco growers. It is argued that exist significant exertion of monopsony power on leaf tobacco market by the cigarettes manufacturers but there is no evidence of the monopoly power exercised by those manufacturers on consumer market (Raper *et al*, 2000). Following the work of Raper *et al.* (2000), Raper and Love (2007) found more specific conclusions applying non-parametric tests showing that cigarettes manufacturers not only have monopsony power but also monopoly power, although small. Moreover the monopsony power is more evident in domestic demand than imported leaf tobacco.

Marketing quota and price support programs were commonly applied under the USA farm policy until 2004 which was the case of tobacco (Dohlman 2010). Thus, there are several works studying that issue, especially about the North Carolina flue-cured tobacco, a type of leaf tobacco whose production is centered in this region and that represents large part of the tobacco production in USA. The quota may be seen as an input for tobacco production whose supply is perfectly inelastic (Rucker *et al.* 1995). Thus, under supply controls and increases on marginal costs *"(...) quota owners unambiguously lose (...)"* while producers[2] gain if marginal costs diverge with higher input. In that case the total rent declines because quota owners lose more than the producers gain (Babcock and Foster 1992). The market supply elasticity for flue-cured tobacco was estimated by Fulginiti and Perrin (1993) in 7.0 higher than estimated by other authors namely Rucker *et al.* (1995). Rucker *et al.* (1995) developed marginal cost functions for the North Carolina counties to estimate the supply response of tobacco production from an elimination of inter-county restrictions on the quota transfer and estimated an aggregate elasticity of 4. The end of the federal tobacco program resulted in a tobacco production increase (Brown *et al.* 2007).

With concern to the firm behavior in markets with addiction considering that the demand is linked over time Showalter (1999) came up with some interesting results. He analyzes a theoretical model for monopolistic behavior in the presence of myopic[3] consumers and shows that future variables will be correlated with current variables, which means that in a market controlled by a monopolist, the anticipated events can affect present consumption due to producer's rational optimization. So, *"(...) the empirically established correlation between future consumption and current consumption found in the rational addiction literature could be the sole result of forward-looking producer behavior (...)".* Contrary to the monopoly model, the author also found that the monopolist might optimally set prices at or even below his marginal cost for some period of time which could be the result of his responses to changes about future events. He also studies the effects of the federal excise tax increase that occurred

[2] Quota owners are the holders of the marketable production quotas and producers pay a quota rate to quota owners for the right to produce a unit of production.
[3] The difference between rational and myopic consumers is in incorporate (or not) the future at the moment of taking decisions. Rational consumers do not ignore the future. For myopic consumers the optimization problem only takes into account the present and the past, but not the future.

in 1983, using data on cigarettes consumption finding that unexpectedly both models (myopic and rational) of consumer demand give nearly the same predictions for per capita consumption and total tax revenues. However the models overestimate actual consumption causing an overestimation of tax revenue increase about 15-20% per year. Regarding price prediction this problem also appears which suggests that supply effects should be considered, i.e., the firms' response to tax changes may be more important than the simple distinction between rational and myopic consumers.

As tobacco is a good with particularly characteristics, since it has addictive properties and potential negative effects on smokers and others health, another type of market failure discussed in literature is the externalities in tobacco market. The health effects are frequently studied on health reports with statistics about deaths and other information published at an international/European level or published by national entities.

Therefore the externalities theme is usually studied in order to explain why regulation is needed. There are three main arguments to consider the tobacco externalities as a market failure: externality that young smokers impose upon themselves (consequences on their future adult persons and influences on adult behavior), irrationality in tobacco consumption and peer effects (Laux 2000). With regard to the peer effects, they are particularly important in the study of the youth smoking. Powell *et al.* (2005)[4] study the direct and indirect effects (via the peer effects) of prices and anti-smoking regulations estimating an economic model more extensive than the standard model for youth smoking determinants. Therefore the authors integrated simultaneously the taxes, other tobacco control policies and peer effects to conclude that peer effects are very important on youth smoking decisions: *"(...) moving a high-school student from a school where no children smoke to a school where one quarter of the youths smoke is found to increase the probability that the youth smokes by about 14.5 percentage point*." Additionally, higher cigarette prices and smoking restrictions influence not only the

[4] To estimate the model, Powell, L. M., J. A. Tauras and H. Ross (2005), "The importance of peer effects, cigarette prices and tobacco control policies for youth smoking behavior", *Journal of Health Economics*, Vol.*24*nº 5, pp.950-968. used Audits & Surveys (A&S) 1996 survey data of high school students in the United States from "The Study of Smoking and Tobacco Use Among Young People". The peer effects are measure trough the calculus of the school smoking prevalence. "*That is, for each student the prevalence of school-based peer smoking is the average prevalence of smoking among all other respondents at their school."*

youth smoking decisions and number of cigarettes smoked, but also the way they are acquired: with higher prices, teens are less likely to become regular smokers but have incentives to borrow cigarettes on "social market" (Katzman *et al.* 2007)[5]. Thus, the current tobacco control policies are ineffective in reaching this group of teens who obtain tobacco trough the social market (Powell *et al.* 2005)

The features of tobacco market described and studied above justify tobacco regulation but the literature also investigates the impact and effectiveness of tobacco control policies. Nations across the world had hardly tried to "fight" tobacco consumption through various tobacco control policies (implemented for more than 20 years). Although the success of the measures and policies is mixed, the price controls seemed to be the most effective measure (Gruber, 2002; Goel and Nelson, 2006). The last 20 years are characterized by a sequence of mergers, acquisitions and privatizations that led to the creation of the largest transnational tobacco companies in terms of volume and market share, as it is now (Bialous and Peeters 2012).

The new research published in the last few years focus on different policies that could be adopted on tobacco market, in particularly on the instruments that affect the producers' profits. It is in this context that it is the major contribution of Gilmore *et al.* (2010) to the topic. These authors suggest the application of a price cap regulation imposed to the tobacco producers in the United Kingdom, without changing retail price. They argue that price cap would control the excessive margins of producers, increase government revenue (with the transfer of the excess profits through tax increases) and also promote benefits to public health ("*(...)preventing downtrading to cheaper products and controlling unwanted industry practices such as cigarette smuggling, price fixing and marketing to the young"*).

Following the previous work, Branston and Gilmore (2014) show that the application of the price cap regulation imposed to tobacco producers is feasible. They determine the current profits of the tobacco companies in the United Kingdom, how much such profits could be reduced by the implementation of the price cap regulation and consequently

[5] The authors used data from the Youth Risk Behavior Survey (USA). This survey distinguishes the youths who actually buy cigarettes of those who borrow.

the government revenue increase. The authors use the profits range[6] evidenced by several European transnational companies operating in more competitive markets (e.g.: L'Oreal, Unilever, Danone, Nestle, Heineken, Carlsberg, etc.) and analyze two scenarios called "conservative scenario", which allowed companies to make returns of 20%, and "optimistic scenario" allowing returns of 12%. The results show that "*Applying a system of price-cap regulation in the UK would raise around £500 million per annum (US $ 750 million*)."

It is very important to understand the relation between the market growth (in value, not volume) and the profits to comprehend the industry behavior and consequently planning effective tobacco control policies. Global consumption is declining but industry' profits continue to increase, which can largely be explained by the industry *"(...) phenomenal pricing power which is now fundamental to its future."* (Gilmore 2012). There have been numerous efforts to align the public health objectives with tobacco companies' actions. Callard and Collishaw (2013) summarize six proposals to do so including "(..*) proposals for new structures through which tobacco products would be supplied, profit controls on the industry and legislated market outcomes"* (the profit control suggestion represents the work of Gilmore *et al.* (2010)). Additionally the different political points of view present on society can be seen as a barrier to the establishment of an optimal policy in the tobacco industry, especially supply-side interventions (Callard and Collishaw 2013). The works made by Gilmore (2012) and Callard and Collishaw (2013) reinforces the need to integrate new methods of regulation on tobacco market and both refer the price cap regulation suggested by Gilmore *et al.* (2010).

2.2. Price cap Regulation

The literature discusses the application of price cap regulation since it was developed in the 1980's by Stephen Littlechild, United Kingdom Treasury economist (Armstrong *et al.* 1994) and applied to British Telecom. Over the years several studies have been published about price cap regulation and this instrument has been largely applied by many countries in several sectors (energy, telecommunications, transports, etc.)

[6] The profitability is measured using EBITA (Earnings before interest, taxation and amortization) margin.

Regulators should regulate firms with market power to avoid the abusive prices that could be set but at the same time the firm's efficiency should also be promoted. The price cap regulation faces these problems (Cowan 2002). Price cap regulation involves fixing a maximum price during a regulatory period, under which the regulated firm can freely set prices. At the end of each regulatory period the regulator adjusts the maximum price considering inflation, efficiency gains and other exogenous costs. The factor representing the efficiency gains is deducted from the price charged in the previous period to regulation. Thus, the regulated firm has incentives to invest on cost reduction and the consumers also benefit from the productivity increases. Moreover, the higher regulatory periods, the higher costs saving incentives are but consumers only later benefit from the efficiency gains. Therefore, price cap regulation has been popular and seems to succeed in its main objective that is to create cost efficiency incentives (Cowan, 2002; Currier, 2007; Sappington and Weisman, 2010).

Usually, the main problem frequently discussed is the difficult on setting the factor that represents the expected productivity increases, the so called X factor. The value of the X factor is usually defined taking into account the comparison between the rate of growth of the firm's input prices and the other firm's long-term productivity performance in the industry, the market competitive forces, negotiations between the firms and the regulator and the regulator's general perspective on the firm efficiency. The definition of the X factor should also consider the consumer's defense, the auto-financing ability and the technological dynamism (Pires and Piccinini, 1998; Currier and Jackson, 2008). Regarding the technological investments, there still remains the challenge to promote long term investment. Therefore price cap regulation "*(...) may be more appropriate for industries without substantial investment requirements where there is excess capacity than for expanding industries with large investment plans.*" (Cowan 2002). Also, sectors with greater technological dynamism (as telecommunications sector for instance) present higher X values than those who technological innovation is slower (Pires and Piccinini 1998). Additionally, if the X factor is set too high, the firm may not cover its costs. On the other hand, if it is set too low the firm could earn abnormal profits and prices still remain excessive. Since the productivity evolution is so important there are different methods to define the X factor such as historical analysis and benchmarking. However *"If the regulator uses the past* *performance of the firm, such as profitability, as a guide to setting the X factor then management incentives will be undermined"* (Treasury 1999).

The plan of price cap regulation includes the definition of the time between the regulation will operate until it is reviewed. The gap between reviews is known as the regulatory lag. This issue is subject to some considerations. A short plan "*can help to ensure that prices do not diverge too far from underlying production costs and that realized earnings do not depart too far from the target level (...)"* and also could discouraged firms to innovate and reduce production costs. *"In particular, if the X factor is re-set frequently to pass on to consumers in the form of lower prices any cost reductions that the regulated firm has achieved, then the firm's incentive to secure these cost reductions will be limited" (Sappington and Weisman 2010).*

Additionally, on dynamic regulatory relationships can arise the ratchet effect. According to this effect the regulated firm has incentives to show less efficient in order to induce higher caps (Resende 1997). *"In a price cap setting it might happen that cost savings (or at least a fraction of them) generated in excess of those anticipated by the regulator are clawed back to consumers through lower prices"*. Therefore, the ratchet effect can origin cycles on cost cutting activity: "(...) *firms' cost cutting activity tends to increase in the early phase of the regulatory cycle, while it weakens as the price review approaches."* (Bottasso and Conti, 2009). Such effect can be the result of the regulator's lack of commitment to a long term contract. "*If the firm by its past performance reveals efficiency, the regulator adjusts the contract to reduce future costly rent given to the firm*." Thus, unless the regulator provides strong incentives to regulated firms, at the beginning of the contract, the efficient firms will tend to mimic the inefficient ones to ensure future rent (Dalen, 1995; Bottasso and Conti, 2009). However, the regulator can use efficiency-improving investment to prevent the ratchet effect: *"if inefficient firms over time catch up with efficient firms due to efficiency-improving investment, future information rent will decrease, thereby reducing efficient firms' incentives to pool with inefficient firms"* (Dalen, 1995)

Another disadvantage is the lack of interest to produce with quality levels: *"(...) it is not clear that regulators can appropriately trade-off price against quality"*. Price cap regulation promotes the cost efficiency but this effort to reduce costs could have an adverse effect on the quality of the good or service produced (Cowan 2002). Because ensure the quality may be expensive, the cost incentives under the price cap regulation may lead to a delivered service quality degradation (Currier and Jackson 2008). Limited by the regulator price, the firm will only invest in quality when the demand increases (and therefore revenue increases) exceed the costs of this investment (Ghirardi 2000). Thus, price caps should be somehow tied up to quality (Brennan 1989). However, there is little evidence that under price cap regulation exists quality degradation since the regulators frequently monitor service quality measures, public the results and consequently threaten with lower prices on next review (Banerjee, 2003; Cowan, 2002)

As said before price cap regulation is usually applied in utilities. A very common scenario in utilities is the existence of partial separation. This separation is a vertical separation which means that the firm is separated in terms of activities practiced and some specific activities are subject to regulation and others are not. In some sectors, the regulated activity is downstream and the upstream activity is deregulated. Through a theoretical model, Reitzes (2007) studied the application of a price cap regulation in that case. The author shows that the imposition of downstream price cap jointly with an appropriate profit sharing rate (between the regulated downstream firm and consumers) can eliminate the market power exercised by the upstream firm, since it can be induced to marginalize the price. Thus, the regulator can indirectly constrain the market power exercised by the upstream affiliate through the regulation system applied to downstream affiliate. However, price cap regulation applied downstream is less effective if the upstream rivals also behave strategically.

The comparison between price cap regulation and other forms of regulation is also discussed in microeconomic literature. Despite the problems and given the advantages of this method the authors argued that price cap regulation is superior to other types of regulation, namely rate of return regulation (Clemenz, 1991; Liston, 1993; Pires and Piccinini, 1998; Vogelsang, 2002; Currier and Jackson, 2008; Sappington and Weisman, 2010). Price cap regulation has been so popular since it provides incentives for cost reduction and promotes an efficient pricing (Vogelsang, 2002). Hence, price cap regulation is more effective than rate-of-return regulation regarding the creation of incentives to promote efficiency since under rate-of-return regulation the firms have no incentives to cost efficiency (Currier and Jackson, 2008). Additionally, Clemenz (1991) sought to study the case where the regulator is not able to observe investment expenditures of a firm who wants to reduce its' production costs and conclude that price cap method *"(...)not only provide stronger incentives for investments in cost reduction than rate-of-return regulation, but that it is also capable of achieving a higher social welfare".*

Chapter 3

Portuguese Tobacco Industry – Market Structure Characterization

This section describes the tobacco industry structure in Portugal mostly using the data from SABI[7] (Iberian Balance Sheet Analysis System). SABI is a database that contains information about companies in Spain and Portugal that goes back to 12 years ago.

On the worldwide stage there are four major transnational companies operating on all phases of the value chain of tobacco industry (excluding Chinese National Tobacco Corporation, a state-owned tobacco company, that owns about 98% of the Chinese market): the Phillip Morris International (PMI), the British American Tobacco, the Japan Tobacco International and Imperial Tobacco, in descending order by size on volume production (Gilmore *et al.* 2010). Moreover PMI is the market leader in cigarettes production and the most profitable company in the world, in this sector. Additionally, around the world there are more than 500 factories that jointly produce 6 trillion cigarettes. In Portugal the cigarette production was 25 billion pieces in 2010 (Eriksen *et al.* 2012).

It is important to note that production and distribution are two distinct markets. Therefore, to find how many companies operate on each market the companies where search by CAE (Economic Activity Classification), which is different among these markets, in Portugal. The data found helped to describe the tobacco industry and will help to define some hypothesis for model's construction.

PMI is the only company of the "Big-Four" group that has a subsidiary in Portugal, called "*A Tabaqueira*". "*A Tabaqueira*" is one of the largest companies in the country

[7] SABI was accessed on February of 2014 to explore Portuguese tobacco industry specifically the number of firms, operational results and market shares. It was used the most recent data which refer to the year of 2012.

and the largest tobacco company in Portugal. British American Tobacco is represented as one of the shareholders of the smallest tobacco company ("*SUT- Sociedade Unificada de Tabacos Lda*.") operating on production market so has almost no impact in Portugal.

On tobacco production[8] the market is highly concentrated with only five companies operating on this market:

- *"Tabaqueira - Empresa Industrial de Tabacos, S.A."*
- *"Empresa Madeirense de Tabacos S.A."*
- *"Fábrica de Tabaco Micaelense S.A."*
- *"STG Portugal, S.A."*
- *"SUT- Sociedade Unificada de Tabacos Lda."*

Of this five only two have higher significance: "*Tabaqueira - Empresa Industrial de Tabacos, S.A.*" and *"Empresa Madeirense de Tabacos S.A."*

It is noteworthy that it is the PMI subsidiary - "*Tabaqueira- Empresa Industrial de Tabacos, S.A*"- that have the greatest market share holding about 45% of the production market. Additionally, *"Fábrica de Tabaco Micaelense S.A."* holds about 23% of production market but is also classified with another CAE[9]. Thus, this company operates not only on production market but also on retail market. Therefore 23% is not an exact value for tobacco production market share.

The distribution market[10] is considered as the wholesale market and not the final place where tobacco is sold (retailers on specialized stores[11]). The PMI subsidiary (which holds the largest market share on production market) has a "sister company" - "*Tabaqueira II, S.A*" that operates on the distribution market. On distribution market it is the PMI subsidiary that has greater expression in relation to other companies, holding about 11% of the market. The remaining firms have all market shares below 5% and more than 50% of the remaining firms have market shares below 1%.

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[8] Production market is classified with CAE 12000.
[9] That company is also classified with CAE 47260, which refers to tobacco retailers on specialized stores.
[10] The distribution market is classified with CAE 46350.
[11] The retail market is classified with CAE 47260.

The main difference between Portuguese tobacco production market and Portuguese tobacco distribution market is the number of firms. The production market is very concentrated while on distribution market there are over two hundred companies. In addition, many of these distributors have more than one CAE which means that they operate and compete on other markets. Thus, the total revenue does not come from only tobacco distribution activity. This distinction allows underline even more the position of the PMI subsidiary.

Regarding the tobacco price, it is know that tobacco is subject to taxation. Therefore, the final price includes the taxes imposed by the Portuguese government. Thus, at the packing process and distribution preparation stages, the final price is already established. In Portugal, about 83% of the retail price is composed by taxes (included the value-added-tax (VAT) and other tobacco taxes) (Nunes 2014), having generated, in 2013, a tax revenue around 1312, 9 € million (DGAIEC 2014).

The "*Imposto sobre o Tabaco (IT)*" is part of the excise taxes group and is applied to the selling price of the cigarette packs.[12] According to the *"Autoridade Tributária e Aduaneira (AT)* the *IT* rates currently in force for cigarettes are 17% for the *Ad Valorem* element and 87,33€ (per 1000 cigarettes) for the specific element.[13] Additionally cigarettes are subject to a minimum excise duty that corresponds to 104% of the tax resultant from the application of the tax rate charged to the most popular price category ("*Código dos Impostos Especiais de Consumo (Decreto-Lei n.º 73/2010, de 21/06 - redacção dada pela Lei n.º 83-C/2013, de 31/12)) ".*

[12] Other types of tobacco as the cigars, cigarillos, fine cut tobacco etc. are also subject to taxation and there have been an increase on taxation levels among those types.

[13] The specific element corresponds to a fixed value per number of pieces (in tobacco case per 1000 cigarettes) while the *Ad-valorem* element corresponds to a fraction of the value taxed, expressed as a percentage.

Chapter 4

Price Cap Regulation - The Model

This chapter describes the model constructed to study the effects of price cap regulation imposed to an upstream firm that sells the product to two downstream firms Furthermore, the analysis of price cap regulation is also developed considering other aspects of the market. Then, the strategic behavior of the upstream firm and the asymmetric costs between downstream firms is also studied.

The structure of the market considered in the model is the following. At the upstream level (the production market) there is a monopolist that sells the product to two downstream firms (the distribution market).[14] Both distributors have to buy from the monopolist. Hence, we assume that there is no alternative supplier of the product.[15] The distributors sell the product to the final consumers.[16]

The upstream firm is subject to price cap regulation. This means that at each period the regulator sets the maximum price allowed for this firm. We consider that initially the regulator announces that it will imposed a price cap on the second period which depends on the price observed in the first period and also on the expected rate of inflation and efficiency gains, as explained in Chapter 2.

Hence the model is developed as a sequential game in order to have a better understanding of the application of the price cap mechanism. At the first stage, firms decide the quantities (as a monopolist in the case of the upstream firm and as Cournot followers in the case of the downstream firms), without any price cap constraint. Then, prices and profits of the first stage are set. At the second stage, firms compete again, and

[14] As described in Chapter 3, the Portuguese tobacco industry is characterized by a highly concentrated production market that we represented by a monopoly. At the distribution market there is competition that we represented by the duopoly in which one of the firms is vertically integrated with the producer ("sisters companies").
[15] We do not consider the possibility of imports, for instance.
[16] In the circuit there are also the retailers between the wholesale distributors and the final consumers. However the retailers are not relevant to the model.

choose the second period quantities subject to a price constraint price. Then, new prices and profits are set.

The model is presented in four different versions. In the first version (the basic model) firms are myopic, that is, when deciding the quantities of each period firms only take into account the profit of that period. Also, in the first version of the model the downstream firms have the same cost function. In the second version it is assumed that the upstream firm decides strategically. This means that the upstream firm takes into account the regulatory process of setting the second period's price cap. Therefore the upstream firm chooses the quantity that maximizes the sum of period 1 and period 2 profits. As in the first version it is assumed that the downstream firms have the same costs. The third version considers that firms are myopic and that the downstream firms have different cost functions. Finally, in the fourth version of the model it is assumed that the upstream firm behaves strategically and that the downstream firms have different costs.

Furthermore it will be considered perfect and complete information. Then, the model is solved by backward induction.

4.1. Hypothesis and variables

The market structure is represented in Figure 1.

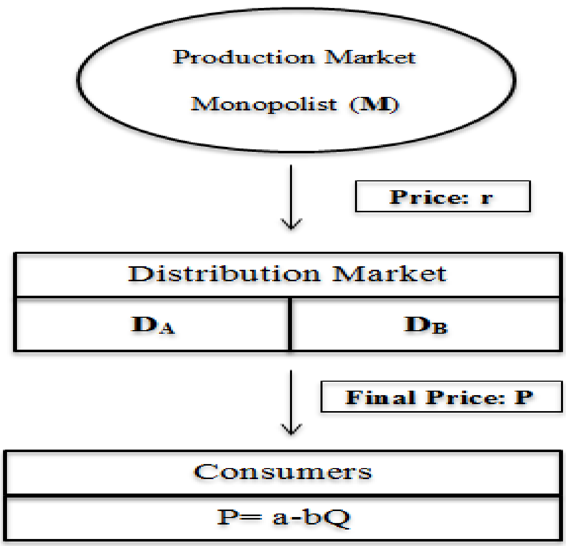

Figure 1: Market Structure

On the production market the monopolist (firm **M**) sells the product at price **r**, to the distributors (firms $\mathbf{D_A}$ and $\mathbf{D_B}$). The distributors sell the product to final consumers.

The demand faced by $\mathbf{D_A}$ and $\mathbf{D_B}$ is assumed to be a linear function express as $\mathbf{P = a - bQ}$, with $\mathbf{Q = q_A + q_B}$ where **Q**, $\mathbf{q_A}$ and $\mathbf{q_B}$ represent the total and individual quantities (for firms $\mathbf{D_A}$ and $\mathbf{D_B}$), respectively, and **a** and **b** are positive parameters.

Additionally it is also assumed that demand function is steady (that is, there are no changes from a period to another) and that the discount rate of future profits is 1, which means that the time value of money is ignored.

Regarding the firms costs we consider that the monopolist has a constant marginal cost given by **c**, with $\mathbf{c < a}$, and fixed costs represented by **F**, with $\mathbf{F > 0}$. The downstream firms' costs only depend on the wholesale price. For simplicity all other downstream costs are normalized to zero.

Then, the profit functions are the following:

Firm M: $$\pi_M = (\mathbf{r - c}) * \mathbf{Q - F} \tag{1}$$

Firm D_A: $$\pi_A = (\mathbf{P - r}) * \mathbf{q_A} \tag{2}$$

Firm D_B: $$\pi_B = (\mathbf{P - r}) * \mathbf{q_B} \tag{3}$$

Notice that for each period, **M** first decides **Q** and then $\mathbf{D_A}$ and $\mathbf{D_B}$ choose $\mathbf{q_A}$ and $\mathbf{q_B}$, respectively. Then, the results of period 1 and 2 are represented as follows: $\mathbf{Q_1}$ and $\mathbf{Q_2}$ represent the total quantity in period 1 and 2, respectively; $\mathbf{q_{1A}}$, $\mathbf{q_{1B}}$, $\mathbf{q_{2A}}$ and $\mathbf{q_{2B}}$, represent the individual quantities for firms $\mathbf{D_A}$ and $\mathbf{D_B}$ in period 1 and period 2, respectively; $\mathbf{r_1}$ and $\mathbf{r_2}$ represent the wholesale prices of period 1 and period 2, respectively, $\mathbf{P_1}$ and $\mathbf{P_2}$ represent the final prices of period 1 and period 2 respectively; finally $\boldsymbol{\pi_{M1}}$, $\boldsymbol{\pi_{1A}}$, $\boldsymbol{\pi_{1B}}$, $\boldsymbol{\pi_{M2}}$, $\boldsymbol{\pi_{2A}}$ and $\boldsymbol{\pi_{2B}}$ represent the firms' profits (for firm **M**, firm $\mathbf{D_A}$

and firm $\mathbf{D_B}$) in periods 1 and 2, respectively. The payoffs of the firms are given by the sum of period's 1 and period's 2 profits.

4.2. Solving the problem - PCR application

Using backward induction there are four steps to solve the model and find the equilibria:

- <u>1st Step</u>: $\mathbf{D_A}$ and $\mathbf{D_B}$ decide $\mathbf{q_{2A}}$ and $\mathbf{q_{2B}}$ (that depend on $\mathbf{r_2}$). Summing $\mathbf{q_{2A}}$ and $\mathbf{q_{2B}}$ it is found the demand faced by **M** on second period.

- <u>2nd Step</u>**:** **M** chooses $\mathbf{Q_2}$, subject to the price constraint. The price constraint depends on $\mathbf{r_1}$, which is a first period variable.

- <u>3rd Step:</u> $\mathbf{D_A}$ and $\mathbf{D_B}$ decide $\mathbf{q_{1A}}$ and $\mathbf{q_{1B}}$ (that depend on $\mathbf{r_1}$). Summing $\mathbf{q_{1A}}$ and $\mathbf{q_{1B}}$ it is found the demand faced by **M** on first period.

- <u>4th Step:</u> **M** chooses $\mathbf{Q_1}$;

The price restriction on the first stage is represented by the following expression: $\mathbf{r_2 = r_1 - \delta}$, where $\mathbf{r_1}$ is the price observed on prior period to regulation and δ symbolizes the net effect of the inflation, expected efficiency gains and exogenous costs. Since the objective of price cap regulation is to reduce the price charged it is assumed that $\delta > \mathbf{0}$.

The aim of building a model with two periods is not only to evaluate the effect of price cap regulation but also to be able to consider that the monopolist could act strategically. Therefore, on period 1 the monopolist can take into account that it will be subject to a price restriction on the following period.

Adding the fact that will be considered the existence of asymmetric costs between the wholesale distributors, we create four scenarios (or four versions of the model) that will help to study each relevant issue inherent to the industry:

- <u>Scenario 1</u>: Symmetric Costs between the Downstream Firms and Upstream Myopic Monopolist;

- Scenario 2: Symmetric Costs between the Downstream Firms and Upstream Strategic Monopolist;

- Scenario 3: Asymmetric Costs between the Downstream Firms and Upstream Myopic Monopolist;

- Scenario 4: Asymmetric Costs between the Downstream Firms and Upstream Strategic Monopolist;

We first describe the first scenario in detail and then highlight the differences for the remaining scenarios.[17]

4.2.1. Scenario 1: Symmetric Costs between Downstream Firms and Upstream Myopic Monopolist

- **1st Step - D_A and D_B decide q_{2A} and q_{2B}:**

Demand faced by $\mathbf{D_A}$ and $\mathbf{D_B}$ is assumed as a linear function represented by $\mathbf{P_2 = a - bQ_2}$, with $\mathbf{Q_2 = q_{2A} + q_{2B}}$. The total costs of the companies operating on distribution market are assumed as: $\mathbf{TC_i = r^*q_i}$, with $\mathbf{i = A, B}$. Hence the total costs of $\mathbf{D_A}$ in period 2 is $\mathbf{TC_A = r_2 * q_{2A}}$ and the profits are expressed by the following expression:

$$\boldsymbol{\pi_{2A} = P_2 * q_{2A} - r_2 * q_{2A}} \tag{4}$$

From the first order condition of the profit maximization problem in order to $\mathbf{q_{2A}}$ it is found the $\mathbf{D_A}$'s best response function[18]:

[17] To solve the mathematical problems it was used the program Scientific Workplace 5.5.

[18] The second order condition of the profit maximization problem is verified. In the following problems this condition is also verified, and therefore we will not mention it.

$$q_{2A} = \frac{a - bq_{2B} - r_2}{2b} \tag{5}$$

As D_A and D_B are identical companies the result is symmetric and D_B's best response function is given by:

$$q_{2B} = \frac{a - bq_{2A} - r_2}{2b} \tag{6}$$

The individual quantities that maximize the profits are obtained solving the system with the two best response functions. The solutions are equal among both companies and expressed by:

$$q_{2A} = q_{2B} = q_2 = \frac{1}{3b}(a - r_2) \tag{7}$$

The total amount produced at the second stage is:

$$Q_2 = q_{2A} + q_{2B} = \frac{2}{3b}(a - r_2) \tag{8}$$

And price r_2 charged in the market is:

$$r_2 = a - \frac{3}{2}bQ_2 \tag{9}$$

- **2^{nd} Step - M chooses Q_2 subject to the price cap constraint**

The equation (8) defined in the previous step represents the demand function of period 2 that it is relevant for the monopolist decision.

Then firm's **M** problem is the following:

$$\text{Max}_{Q_2}\ \pi_{M2} = r_2 * Q_2 - (F + cQ_2)$$

$$\text{s.t. } r_2 \leq r_1 - \delta$$

The Lagrangean function is given by:

$$L = Q_2 * (a - \frac{3}{2}bQ_2) - (F + cQ_2) + \lambda(a - \frac{3}{2}bQ_2 - r_1 + \delta)$$

Remember that parameter δ denotes the net effect of the inflation, expected efficiency gains and exogenous costs and $\delta > 0$. From the first order conditions it is found the quantity produced by **M** on second period:

$$Q_2 = \frac{1}{3b}(2a + 2\delta - 2r_1) \tag{10}$$

Notice that Q_2 depends on the wholesale price of period 1 (r_1).

- **3rd Step - D_A and D_B decide q_{1A} and q_{1B}**

In this step it is applied a similar reasoning of the first step but applied to the first period decisions.

Therefore, the demand faced by D_A and D_B is $P_1 = a - bQ_1$, with $Q_1 = q_{1A} + q_{1B}$. The total costs of D_A are $TC_A = r_1 * q_{1A}$ and the profit expression is given by:

$$\pi_{1A} = P_1 * q_{1A} - r_1 * q_{1A} \tag{11}$$

The D_A's and D_B's best response functions are:

$$q_{1A} = \frac{a - bq_{1B} - r_1}{2b} \tag{12}$$

$$q_{1B} = \frac{a - bq_{1A} - r_1}{2b} \tag{13}$$

Again, the individual quantities that maximize the profits of the firms D_A and D_B are equal and expressed by:

$$q_{1A} = q_{1B} = q_1 = \frac{1}{3b}(a - r_1) \tag{14}$$

The total quantity is given by:

$$Q_1 = \frac{2}{3b}(a - r_1) \tag{15}$$

And the price $\mathbf{r_1}$ expression is:

$$r_1 = a - \frac{3}{2}bQ_1 \tag{16}$$

- **4^{th} Step - M chooses Q_1**

At the fourth step the monopolist cost function is $\mathbf{TC_{M1} = F + c^* Q_1}$ and the profit expression is $\boldsymbol{\pi_{M1} = r_1{*}Q_1 - (F + cQ_1)}$.

The inverse demand function faced by the monopolist was determined in the previous step and is given by equation (16)**.** Note that here the profit maximization problem of the monopolist does not have any price constraint. Then, the first order condition of this problem leads to a total quantity produced by **M** of:

$$Q_1 = \frac{1}{3b}(a - c) \tag{17}$$

In order to obtain the equilibrium values for all the other quantities and prices we substitute the value of $\mathbf{Q_1}$ into the previous expressions. The equilibrium values are the following:

- **First period**

Total quantity: $Q_1 = \frac{1}{3b}(a - c)$

Individual quantities: $q_{1A} = q_{1B} = \frac{1}{6b}(a - c)$

Prices: $r_1 = \frac{1}{2}a + \frac{1}{2}c$ and $P_1 = \frac{2}{3}a + \frac{1}{3}c$

Firm **M** profits: $\pi_{M1} = \frac{1}{6b}(a^2 - 2ac + c^2 - 6Fb)$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\pi_{1A} = \pi_{1B} = \frac{1}{36b}(a - c)^2$

- **Second period**

Total quantity: $Q_2 = \frac{1}{3b}(a - c + 2\delta)$

Individual quantities: $q_{2A} = q_{2B} = \frac{1}{6b}(a - c + 2\delta)$

Prices: $r_2 = \frac{1}{2}a + \frac{1}{2}c - \delta$ and $P_2 = \frac{2}{3}a + \frac{1}{3}c - \frac{2}{3}\delta$

Firm **M** profits: $\pi_{M2} = \frac{1}{6b}(a^2 - 2ac + c^2 - 4\delta^2 - 6Fb)$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\pi_{2A} = \pi_{2B} = \frac{1}{36b}(a - c + 2\delta)^2$

4.2.2. Scenario 2: Symmetric Costs between Downstream Firms and Upstream Strategic Monopolist

On scenario 2 it is the monopolist behavior that differs from the first scenario, which means that the monopolist chooses the quantities of period 1 and 2 that maximize the sum of the profits in period 1 and 2, given by:

$$\Pi_M = r_1 * Q_1 - (F + cQ_1) + r_2 * Q_2 - (F + cQ_2) \qquad (18)$$

As on previous scenario, firms $\mathbf{D_A}$ and $\mathbf{D_B}$ have identical costs. Thus, at the first step firms $\mathbf{D_A}$ and $\mathbf{D_B}$ choose $\mathbf{q_{2A}}$ and $\mathbf{q_{2B}}$ that maximize their individual profits. Then, we reach the same results as in scenario 1 given by the equations (7) and (8).

At the second step, firm **M** chooses $\mathbf{Q_2}$ maximizing Π_M subject to the price cap constraint and considering the inverse demand function derived on previous step expressed by equation (9). Then, the firm **M** maximization problem is the following:

$$\text{Max}_{Q2} \ \Pi_M = r_1 * Q_1 - (F + cQ_1) + r_2 * Q_2 - (F + cQ_2)$$

$$\text{s.t. } r_2 \leq r_1 - \delta$$

The Lagrange function is:

$$\mathbf{L = r_1 * Q_1 - (F + cQ_1) + Q_2 * (a - \frac{3}{2}bQ_2) - (F + cQ_2) + \lambda(a - \frac{3}{2}bQ_2 - r_1 + \delta)}$$

From the first order conditions we obtained the $\mathbf{Q_2}$ that maximizes firm's **M** profit that is also the same that on first scenario and given by the equation (10).

Then, at the third step firms $\mathbf{D_A}$ and $\mathbf{D_B}$ choose the first period quantities, in the same way as in the first scenario. The individual quantities that maximize the profits are equal for the firms and given by equation (14). Hence the total quantity is expressed by equation (15).

At the fourth step firm **M** chooses $\mathbf{Q_1}$ in order to maximize Π_M. On this maximization problem **M** have to consider the inverse demand functions derived on the previous steps and the $\mathbf{Q_2}$ found on second step through the Lagrangean first order conditions, (expression that depends on $\mathbf{r_1}$ which in turns depends on $\mathbf{Q_1}$)

Then, the firm **M** problem on first period is the following:

$$\text{Max}_{\mathbf{Q1}} \ \mathbf{\Pi_M = r_1 * Q_1 - (F + cQ_1) + r_2 * Q_2 - (F + cQ_2)}$$

with $\mathbf{r_1 = a - \frac{3}{2}bQ_1}$, $\mathbf{r_2 = a - \frac{3}{2}bQ_2}$ and $\mathbf{Q_2 = \frac{1}{3b}(2a + 2\delta - 2r_1)}$

Thus, the equilibrium quantity is $\mathbf{Q_1 = \frac{1}{3b}(a - c - \delta)}$.

Notice that the parameter $\boldsymbol{\delta}$, which belong to the price constraint applied on second period, has an impact on the equilibrium quantity of the first period.

The equilibrium quantities and prices are now obtained by backward substitution and are given by:

- **First Period**

Total quantity: $\mathbf{Q_1 = \frac{1}{3b}(a - c - \delta)}$

Individual quantities: $\mathbf{q_{1A} = q_{1B} = \frac{1}{6b}(a - c - \delta)}$

Prices: $\mathbf{r_1 = \frac{1}{2}a + \frac{1}{2}c + \frac{1}{2}\delta}$ and $\mathbf{P_1 = \frac{2}{3}a + \frac{1}{3}c + \frac{1}{3}\delta}$

Firm **M** profits: $\mathbf{\Pi_M = \frac{1}{3b}(a^2 - 2ac + c^2 - \delta^2 - 6Fb)}$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\mathbf{\pi_{1A} = \pi_{1B} = \frac{1}{36b}(c - a + \delta)^2}$

- **Second Period**

Total quantity: $\mathbf{Q_2 = \frac{1}{3b}(a - c + \delta)}$,

Individual quantities: $\mathbf{q_{2A} = q_{2B} = \frac{1}{6b}(a - c + \delta)}$

Prices: $\mathbf{r_2 = \frac{1}{2}a + \frac{1}{2}c - \frac{1}{2}\delta}$ and $\mathbf{P_2 = \frac{2}{3}a + \frac{1}{3}c - \frac{1}{3}\delta}$

Firm **M** profits: $\mathbf{\Pi_M = \frac{1}{3b}(a^2 - 2ac + c^2 - \delta^2 - 6Fb)}$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\mathbf{\pi_{2A} = \pi_{2B} = \frac{1}{36b}(a - c + \delta)^2}$

4.2.3. Scenario 3: Asymmetric Costs between Downstream Firms and Upstream Myopic Monopolist

Here it is studied the effects of asymmetric costs between $\mathbf{D_A}$ and $\mathbf{D_B}$. Without loss of generality it is assumed that $\mathbf{D_A}$ is the more efficient company only bearing the wholesale price as unitary cost. Differently, besides the wholesale price, firm $\mathbf{D_B}$ has an additional unitary cost of **e**, with $\mathbf{e > 0}$. Then $\mathbf{D_B}$'s cost function is given by $\mathbf{TC_B = (r_2 + e) * q_{2B}}$. This function indicates that the marginal cost of producing one unit of output is higher, on the value **e,** for $\mathbf{D_B}$ than for $\mathbf{D_A}$. Thus, the profit function of $\mathbf{D_B}$ is

$$\pi_{2B} = (P_2 - r_2 - e) * q_{2B} \tag{19}$$

Considering again the Cournot behavior for each firm the $\mathbf{D_A}$'s best response function is again given by equation (5).

Contrary to what happens to firm $\mathbf{D_A}$, the best response function of firm $\mathbf{D_B}$ is different from the previous scenarios. By maximizing $\boldsymbol{\pi_{2B}}$ in order to $\mathbf{q_{2B}}$ it is found the $\mathbf{D_B}$'s best response function:

$$q_{2B} = \frac{a - bq_{2A} - r_2 - e}{2b}. \tag{20}$$

Solving the system with both best response functions we obtain the individual quantities produced by $\mathbf{D_A}$ and $\mathbf{D_B}$:

$$q_{2A} = \frac{1}{3b}(a + e - r_2) \tag{21}$$

$$q_{2B} = \frac{1}{3b}(a - 2e - r_2) \tag{22}$$

Thus, the total quantity is:

$$Q_2 = q_{2A} + q_{2B} = \frac{1}{3b}(2a - e - 2r_2) \tag{23}$$

And the derived inverse demand faced by **M** is now expressed by:

$$r_2 = a - \frac{1}{2}e - \frac{3}{2}bQ_2 \tag{24}$$

Following the second step of first scenario the maximization problem of firm **M** is:

$$\text{Max}_{\mathbf{Q2}}\ \boldsymbol{\pi}_{\mathbf{M2}} = \mathbf{r_2 * Q_2 - (F + cQ_2)}$$

$$\text{s.t. } \mathbf{r_2 \leq r_1 - \delta}$$

The Lagrangean function is now given by:

$$\mathbf{L = Q_2 * (a - \frac{1}{2}e - \frac{3}{2}bQ_2) - (F + cQ_2) + \lambda(a - \frac{1}{2}e - \frac{3}{2}bQ_2 - r_1 + \delta)}$$

From the first order conditions it is found the total quantity produced **M** on second period:

$$\mathbf{Q_2 = \frac{1}{3b}(2a + 2\delta - 2r_1 - e).} \tag{25}$$

Notice that, in this scenario, $\mathbf{Q_2}$ is influenced not only by the first period wholesale price ($\mathbf{r_1}$) and the parameter δ, that denotes the price cap action (as on the other scenarios), but also by the constant **e** that reflects the cost asymmetry between downstream firms.

Considering now the first period and using the same reasoning as in the first step, in third step is obtained the best response functions of firms $\mathbf{D_A}$ and $\mathbf{D_B}$ that are given by:

$$\mathbf{q_{1A} = \frac{a - bq_{1B} - r_1}{2b}} \tag{26}$$

$$\mathbf{q_{1B} = \frac{a - bq_{1A} - r_1 - e}{2b}} \tag{27}$$

Solving the system with the best response functions, the quantities that maximize the individual profits of $\mathbf{D_A}$ and $\mathbf{D_B}$ are:

$$q_{1A} = \frac{1}{3b}(a + e - r_1) \tag{28}$$

$$q_{1B} = \frac{1}{3b}(a - 2e - r_1). \tag{29}$$

Thus, the total quantity produced on first scenario is given by:

$$Q_1 = q_{1A} + q_{1B} = \frac{1}{3b}(2a - e - 2r_1) \tag{30}$$

And the price $\mathbf{r_1}$ expression is:

$$r_1 = a - \frac{1}{2}e - \frac{3}{2}bQ_1 \tag{31}$$

In the fourth step firm **M** maximize $\boldsymbol{\pi_{M1}}$ in order to $\mathbf{Q_1}$, considering the price $\mathbf{r_1}$ defined by equation (31), leading to the choice of $Q_1 = \frac{1}{6b}(2a - 2c - e)$.

The equilibrium values are obtained by backward substitution and are the following:

- **First Period**

Total quantity: $Q_1 = \frac{1}{6b}(2a - 2c - e)$

Individual quantities: $q_{1A} = \frac{1}{12b}(2a - 2c + 5e)$ and $q_{1B} = \frac{1}{12b}(2a - 2c - 7e)$

Prices: $r_1 = \frac{1}{2}a + \frac{1}{2}c - \frac{1}{4}e$ and $P_1 = \frac{2}{3}a + \frac{1}{3}c + \frac{1}{6}e$

Firm **M** profits: $\pi_{M1} = \frac{1}{3b}(4a^2 - 8ac - 4ea + 4c^2 + 4ec + e^2 - 24Fb)$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\pi_{1A} = \frac{1}{144b}(2a - 2c + 5e)^2$ and $\pi_{1B} = \frac{1}{144b}(2c - 2a + 7e)^2$

- **Second Period**

Total quantity: $\mathbf{Q_2 = \frac{1}{6b}(2a - 2c + 4\delta - e)}$

Individual quantities: $\mathbf{q_{2A} = \frac{1}{12b}(2a - 2c + 4\delta + 5e)}$ and $\mathbf{q_{2B} = \frac{1}{12b}(2a - 2c + 4\delta - 7e)}$

Prices: $\mathbf{r_2 = \frac{1}{2}a + \frac{1}{2}c - \frac{1}{4}e - \delta}$ and $\mathbf{P_2 = \frac{2}{3}a + \frac{1}{3}c - \frac{2}{3}\delta + \frac{1}{6}e}$

Firm **M** profits: $\mathbf{\pi_{M2} = \frac{1}{24b}(4a^2 - 8ac - 4ea + 4c^2 + 4ec - 16\delta^2 + e^2 - 24Fb)}$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\mathbf{\pi_{2A} = \frac{1}{144b}(2a - 2c + 4\delta + 5e)^2}$ and $\mathbf{\pi_{2B} = \frac{1}{144b}(2a - 2c + 4\delta - 7e)^2}$

4.2.4. Scenario 4: Asymmetric Costs between Downstream Firms and Upstream Strategic Monopolist

In this scenario it is studied the simultaneous existence of asymmetric costs between wholesalers and the monopolist strategic behavior.

As on third scenario, firms $\mathbf{D_A}$ and $\mathbf{D_B}$ have asymmetric costs. Thus, at the first step firms $\mathbf{D_A}$ and $\mathbf{D_B}$ choose the second period quantities that maximize their individual profits. Then, we reach the same results as in scenario 3 given by equations (21) and (22) for individual quantities and by equation (23) for the total quantity.

Following the second scenario, **M** chooses the quantities $\mathbf{Q_1}$ and $\mathbf{Q_2}$ that maximize the sum of the profits in period 1 and 2 (Π_M), expressed by equation (18).

Thus, at the second step, firm **M** chooses $\mathbf{Q_2}$ maximizing Π_M subject to the price cap constraint and considering the inverse demand function derived on previous step equal to equation (24). Then, the firm **M** problem is the following:

$$\text{Max}_{\mathbf{Q2}}\ \mathbf{\Pi_M = r_1 * Q_1 - (F + cQ_1) + r_2 * Q_2 - (F + cQ_2)}$$

$$\text{s.t } \mathbf{r_2 \leq r_1 - \delta}$$

The Lagrange function is:

$$\mathbf{L = r_1 * Q_1 - (F + cQ_1) + Q_2 * (a - \frac{1}{2}e - \frac{3}{2}bQ_2) - (F + cQ_2) + \lambda(a - \frac{1}{2}e - \frac{3}{2}bQ_2 - r_1 + \delta)}$$

From the first order conditions is obtained the $\mathbf{Q_2}$ that maximizes firm's **M** profits which is the same as in scenario 3 and given by equation (25).

In third step firms $\mathbf{D_A}$ and $\mathbf{D_B}$ decide $\mathbf{q_{1A}}$ and $\mathbf{q_{1B}}$, respectively. Then, we reach the same results as in scenario 3: equations (28) and (29). Hence the total quantity is given by equation (30).

As on second scenario**,** at the fourth step firm **M** chooses $\mathbf{Q_1}$ in order to maximize $\mathbf{\Pi_M}$ considering the inverse demand functions and the second period quantity that depends on the wholesale price charged on first period**.**

Then, the firm **M** maximization problem on first period is the following:

$$\text{Max}_{\mathbf{Q1}} \quad \mathbf{\Pi_M = r_1 * Q_1 - (F + cQ_1) + r_2 * Q_2 - (F + cQ_2)}$$

with $\mathbf{r_1 = a - \frac{1}{2}e \quad \frac{3}{2}bQ_1}$, $\mathbf{r_2 = a - \frac{1}{2}e - \frac{3}{2}bQ_2}$ and $\mathbf{Q_2 = \frac{1}{3b}(2a + 2\delta - 2r_1 - e)}$

Thus, the equilibrium quantity is $\mathbf{Q_1 = \frac{1}{6b}(2a - 2c - 2\delta - e)}$. Therefore, the equilibrium total quantity produced on first period depends not only on the $\boldsymbol{\delta}$ parameter of the price constraint restriction but also on the constant **e**, which reflects the costs asymmetry on distribution market.

By backward substitution the equilibrium values of the fourth scenario are the following:

- **First Period**:

<u>Total quantity</u>: $\mathbf{Q_1 = \frac{1}{6b}(2a - 2c - 2\delta - e)}$

<u>Individual quantities</u>: $\mathbf{q_{1A} = \frac{1}{12b}(2a - 2c - 2\delta + 5e)}$ and $\mathbf{q_{1B} = \frac{1}{12b}(2a - 2c - 2\delta - 7e)}$

Prices: $\mathbf{r_1 = \frac{1}{2}a + \frac{1}{2}c + \frac{1}{2}\delta - \frac{1}{4}e}$ and $\mathbf{P_1 = \frac{2}{3}a + \frac{1}{3}c + \frac{1}{3}\delta + \frac{1}{6}e}$

Firm **M** profits: $\mathbf{\Pi_M = \frac{1}{12b}(4a^2 - 8ac - 4ea + 4c^2 + 4ec - 4\delta^2 + e^2 - 24Fb)}$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\mathbf{\pi_{1A} = \frac{1}{144b}(2c - 2a + 2\delta + 5e)^2}$ and $\mathbf{\pi_{1B} = \frac{1}{144b}(2c - 2a + 2\delta + 7e)^2}$

- **Second Period**

Total quantity: $\mathbf{Q_2 = \frac{1}{6b}(2a - 2c + 2\delta - e)}$

Individual quantities: $\mathbf{q_{2A} = \frac{1}{12b}(2a - 2c + 2\delta + 5e)}$ and $\mathbf{q_{2B} = \frac{1}{12b}(2a - 2c + 2\delta - 7e)}$

Prices: $\mathbf{r_2 = \frac{1}{2}a + \frac{1}{2}c - \frac{1}{2}\delta - \frac{1}{4}e}$ and $\mathbf{P_2 = \frac{2}{3}a + \frac{1}{3}c - \frac{1}{3}\delta + \frac{1}{6}e}$

Firm **M** profits: $\mathbf{\Pi_M = \frac{1}{12b}(4a^2 - 8ac - 4ea + 4c^2 + 4ec - 4\delta^2 + e^2 - 24Fb)}$

Firms $\mathbf{D_A}$ and $\mathbf{D_B}$ profits: $\mathbf{\pi_{2A} = \frac{1}{144b}(2a - 2c + 2\delta + 5e)^2}$ and $\mathbf{\pi_{2B} = \frac{1}{144b}(2a - 2c + 2\delta - 7e)^2}$

4.3. Model's results

In this section we present the results of each scenario and compare them in order to analyze the effects of price cap regulation, cost asymmetry and monopolist strategic behavior.

The results are summarized in a single table that can be found in the Appendix A.

From the comparison of the results we conclude that there is a result which is verified in all scenarios. It is observed that $\mathbf{q_{2A}}$, $\mathbf{q_{2B}}$ and $\mathbf{Q_2}$ are always higher than $\mathbf{q_{1A}}$, $\mathbf{q_{1B}}$ and $\mathbf{Q_1}$. Moreover, $\mathbf{r_2}$ and $\mathbf{P_2}$ are always lower than $\mathbf{r_1}$ and $\mathbf{P_1}$. These results mirror the action of price cap regulation on the second period. With a maximum price on the second period, that by definition is lower than the price observed on the previous period, quantities rise on the second period.

In the following description of the results we take the simplest scenario, scenario 1, as the baseline scenario that will be compared with the others scenarios.

In order to analyze the effects of the monopolist strategic behavior we compare scenarios 1 and 2. Thus, we compare the situation where the monopolist does not take into account the price regulation of the second period with the situation where the monopolist strategically sets the quantity of the first period considering the second period price cap. The Table 1 shows the results for those scenarios on both periods:

	Results				
	Period 1		**Period 2**		
	Scenario 1	**Scenario 2**		**Scenario 1**	**Scenario 2**
$\mathbf{Q_1}$	$\frac{1}{3b}\alpha$	$\frac{1}{3b}(\alpha-\delta)$	$\mathbf{Q_2}$	$\frac{1}{3b}(\alpha+2\delta)$	$\frac{1}{3b}(\alpha+\delta)$
$\mathbf{r_1}$	$\frac{1}{2}a+\frac{1}{2}c$	$\frac{1}{2}a+\frac{1}{2}c+\frac{1}{2}\delta$	$\mathbf{r_2}$	$\frac{1}{2}a+\frac{1}{2}c-\delta$	$\frac{1}{2}a+\frac{1}{2}c-\frac{1}{2}\delta$
π_{M1}	$\frac{1}{6b}k$	$\frac{1}{3b}(k-\delta^2)$	π_{M2}	$\frac{1}{6b}(k-4\delta^2)$	$\frac{1}{3b}(k-\delta^2)$
$\mathbf{q_{1A}}$	$\frac{1}{6b}\alpha$	$\frac{1}{6b}(\alpha-\delta)$	$\mathbf{q_{2A}}$	$\frac{1}{6b}(\alpha+2\delta)$	$\frac{1}{6b}(\alpha+\delta)$
$\mathbf{q_{1B}}$			$\mathbf{q_{2B}}$		
π_{1A}	$\frac{1}{36b}\alpha^2$	$\frac{1}{36}(-\alpha+\delta)^2$	π_{2A}	$\frac{1}{36b}(\alpha+2\delta)^2$	$\frac{1}{36b}(\alpha+\delta)^2$
π_{1B}			π_{2B}		
$\mathbf{P_1}$	$\frac{2}{3}a+\frac{1}{3}c$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{3}\delta$	$\mathbf{P_2}$	$\frac{2}{3}a+\frac{1}{3}c-\frac{2}{3}\delta$	$\frac{2}{3}a+\frac{1}{3}c-\frac{1}{3}\delta$

Where $\alpha=(a-c)$ and $k=a^2-2ac+c^2-6Fb$ with $\alpha>0$ and $k>0$

Table 1: Results Scenario 1 vs Scenario 2

First, all the results of scenario 2 reflect the monopolist strategic behavior since the parameter δ influences the first period variables. Firm **M** decides $\mathbf{Q_1}$ knowing that he will be subject to regulation and so the variables are evidence of that behavior.

One of the most important results is the value of the monopolist profits. On scenario 1, the first period profits are higher than the second's period, as a consequence of the price cap regulation. However, although the quantities of the first period are lower than the quantities of the second period, the price charged by **M** on first period, $\mathbf{r_1}$, is higher than the price of the second period, $\mathbf{r_2}$, which compensates the lower quantities, produced and sold. Differently, on scenario 2, firm **M** has the same profits on both periods which reflect his strategic action. Predicting that he will be subject to a price restriction on the next period, and to mitigate his losses, he anticipates and chooses $\mathbf{Q_1}$ taking into account that fact.

Additionally, on the second period, the monopolist profits are lower on scenario 1 than on scenario 2, which reinforces the importance of **M**'s strategic action. The same happens on first period, if $\mathbf{k > 2\delta^2}$. Moreover, the sum of the profits of periods 1 and 2 is higher on scenario 2 than on scenario 1. Thus, firm **M** has an advantage on thinking strategically and maximizes his profits taking account both periods.

Furthermore, on scenario 2, as **M** acts strategically, he charges a higher wholesale price than on first scenario, on both periods.

Finally, as the distribution companies have symmetric costs, they produced the same quantities and consequently have the same profits on both periods, in each scenario. However, on scenario 1 the quantities (and consequently the profits) are higher than on scenario 2, which means that when the monopolist behave strategically, he charges an higher **r** and then $\mathbf{D_A}$ and $\mathbf{D_B}$ are not willing to buy the same quantities than on scenario 1.

It is curious to note that the increase of the wholesale price from first to second scenario is $\mathbf{\frac{1}{2}\delta}$ on both periods (when **M** behaves strategically $\mathbf{r_1}$ and $\mathbf{r_2}$ are both influenced by the parameter δ). However, on scenario 2, and comparing the first period with the second period, $\mathbf{r_1}$ increase $\mathbf{\frac{1}{2}\delta}$ while $\mathbf{r_2}$ decrease by the same amount of the $\mathbf{r_1}$ increase. This fact reflects the monopolist action to recover the losses on second period: he charges a higher price on first period exactly by the same amount that he will have to decrease the price on next period when he will suffer with the price regulation.

Furthermore, as the distributors have to pay a higher **r** when **M** behaves strategically, they have to charge a higher **P**. Thus, in scenario 2 the final prices are higher than on scenario 1, on both periods (by the amount of $\mathbf{\frac{1}{3}\delta}$). Again, on scenario 2 and comparing the first period with the second, $\mathbf{P_1}$ increase $\frac{1}{3}\delta$ while $\mathbf{P_2}$ decrease by the same amount of the increase of $\mathbf{P_1}$.

An identical analysis could be done between scenarios 3 and 4, where is assumed that $\mathbf{D_A}$ and $\mathbf{D_B}$ have asymmetric costs on both scenarios and the difference is if **M** acts strategically or not. In this comparison what is different from the previous comparison is the condition that assures that the firm **M** profits are lower on scenario 3 than on scenario 4, in first period. That condition is given by $\beta > 8\delta^2$.

To analyze the effect of cost asymmetry between $\mathbf{D_A}$ and $\mathbf{D_B}$ we compare scenarios 1 and 3. These results are synthetized on table 2.

	Results				
	Scenario 1	**Scenario 3**		**Scenario 1**	**Scenario 3**
	Period 1			**Period 2**	
$\mathbf{Q_1}$	$\frac{1}{3b}\alpha$	$\frac{1}{6b}(2\alpha - e)$	$\mathbf{Q_2}$	$\frac{1}{3b}(\alpha + 2\delta)$	$\frac{1}{6b}(2\alpha + 4\delta - e)$
$\mathbf{r_1}$	$\frac{1}{2}a + \frac{1}{2}c$	$\frac{1}{2}a + \frac{1}{2}c - \frac{1}{4}e$	$\mathbf{r_2}$	$\frac{1}{2}a + \frac{1}{2}c - \delta$	$\frac{1}{2}a + \frac{1}{2}c - \frac{1}{4}e - \delta$
π_{M1}	$\frac{1}{6b}k$	$\frac{1}{24b}\beta$	π_{M2}	$\frac{1}{6b}(k - 4\delta^2)$	$\frac{1}{24b}(\beta - 16\delta^2)$
q_{1A}	$\frac{1}{6b}\alpha$	$\frac{1}{12b}(2\alpha + 5e)$	q_{2A}	$\frac{1}{6b}(\alpha + 2\delta)$	$\frac{1}{12b}(2\alpha + 4\delta + 5e)$
q_{1B}		$\frac{1}{12b}(2\alpha - 7e)$	q_{2B}		$\frac{1}{12b}(2\alpha + 4\delta - 7e)$
π_{1A}	$\frac{1}{36b}\alpha^2$	$\frac{1}{144b}(2\alpha + 5e)^2$	π_{2A}	$\frac{1}{36b}(\alpha + 2\delta)^2$	$\frac{1}{144b}(2\alpha + 4\delta + 5e)^2$
π_{1B}		$\frac{1}{144b}(-2\alpha + 7e)^2$	π_{2B}		$\frac{1}{144b}(2\alpha + 4\delta - 7e)^2$
$\mathbf{P_1}$	$\frac{2}{3}a + \frac{1}{3}c$	$\frac{2}{3}a + \frac{1}{3}c + \frac{1}{6}e$	$\mathbf{P_2}$	$\frac{2}{3}a + \frac{1}{3}c - \frac{2}{3}\delta$	$\frac{2}{3}a + \frac{1}{3}c - \frac{2}{3}\delta + \frac{1}{6}e$

Where $\beta = 4k - 4ea + 4ec + e^2$

Table 2: Results Scenario 1 vs Scenario 3

The immediate outcome of asymmetric costs is the difference between the individual quantities produced and the different profits among the distribution companies, $\mathbf{D_A}$ and

$\mathbf{D_B}$. This difference does not happen on first scenario, where they produced exactly the same quantities and earned the same profits.

On scenario 3, $\mathbf{D_A}$, as the most efficient firm, produces more than $\mathbf{D_B}$, on both periods and the $\mathbf{D_A}$ profits are higher than $\mathbf{D_B}$'s. Moreover $\mathbf{D_A}$ produces more on scenario 3 comparing with scenario 1 and $\mathbf{D_B}$ reduces his production. Consequently, the profits of $\mathbf{D_A}$ are higher on scenario 3 and the profits of $\mathbf{D_B}$ are smaller. This is explained not only by the individual quantities produced but also by the value of the wholesale price **r**. The price **r** on both periods is lower on scenario 3. Then $\mathbf{D_A}$ has higher profits on scenario 3 because he produces more at a lower cost. $\mathbf{D_B}$, despite the price **r** reduction, has an additional cost, **e**, that does not allow it to produce as much as on scenario 1 and thus his profits fall. Thus, the effects of asymmetric costs are amplified by the reduction of prices in the upstream market.

Additionally, the final prices, $\mathbf{P_1}$ and $\mathbf{P_2}$ are greater on scenario 3, on both periods. This fact also helped to explain the higher profits of $\mathbf{D_A}$ (produces more at a lower cost production and charged a higher price to its customers). Contrarily to what happens on scenarios 1 and 2, the action of the upstream monopolist has inverse effects on final prices: the wholesale prices are lower on scenario 3 than on scenario 1 but final prices are higher.

The value of the total quantity, on both periods, is lower on scenario 3 than on scenario 1 which means that the total amount produced is inferior when the companies have asymmetric costs. With the price **r** reduction $\mathbf{D_A}$ increases its production and $\mathbf{D_B}$ reduces their production but still continue to buy. However the $\mathbf{D_B}$ reduction is higher than the increase of $\mathbf{D_A}$. Then the total quantity decrease. The value of total quantity is also explained by the value of the final prices: with higher prices the demand decreases.

Regarding the monopolist profits we conclude that if the cost difference is too high, i.e., if $\mathbf{e > 4(a - c)}$, the **M** profits are higher on scenario 3, on both periods. Therefore, the sum of the first and second period's profits is also higher on scenario 3 than on scenario 1 if the previous condition is satisfied. Thus, it could be profitable for firm **M** if there are asymmetric costs between his customers. The fact of the monopolist decreases the price charged leads to not only more incentives to $\mathbf{D_A}$ to buy but also to $\mathbf{D_B}$ still continue to buy, despite its cost inefficiency.

Among scenarios 2 and 4 it is possible to make the same analysis. In that comparison if $\boldsymbol{\beta > 4k}$ it is guaranteed that the sum of periods 1 and 2 profits is higher on scenario 4 than on scenario 2.

Finally, the last comparison was made between the base scenario with the most complex scenario, scenario 4 where it is studied the case of **M**'s strategic behavior with the simultaneous existence of asymmetric costs. Table 3 expresses the results for scenarios 1 and 4.

	Results				
	Scenario 1	Scenario 4		Scenario 1	Scenario 4
	Period 1			Period 2	
Q_1	$\frac{1}{3b}\alpha$	$\frac{1}{6b}(2\alpha-2\delta-e)$	Q_2	$\frac{1}{3b}(\alpha+2\delta)$	$\frac{1}{6b}(2\alpha+2\delta-e)$
r_1	$\frac{1}{2}a+\frac{1}{2}c$	$\frac{1}{2}a+\frac{1}{2}c+\frac{1}{2}\delta-\frac{1}{4}e$	r_2	$\frac{1}{2}a+\frac{1}{2}c-\delta$	$\frac{1}{2}a+\frac{1}{2}c-\frac{1}{2}\delta-\frac{1}{4}e$
π_{M1}	$\frac{1}{6b}k$	$\frac{1}{12b}(\beta-4\delta^2)$	π_{M2}	$\frac{1}{6b}(k-4\delta^2)$	$\frac{1}{24b}(\beta-4\delta^2)$
q_{1A}	$\frac{1}{6b}\alpha$	$\frac{1}{12b}(2\alpha-2\delta+5e)$	q_{2A}	$\frac{1}{6b}(\alpha+2\delta)$	$\frac{1}{12b}(2\alpha-2\delta+5e)$
q_{1B}		$\frac{1}{12b}(2\alpha-2\delta-7e)$	q_{2B}		$\frac{1}{12b}(2\alpha-2\delta-7e)$
π_{1A}	$\frac{1}{36b}\alpha^2$	$\frac{1}{144b}(-2\alpha+2\delta-5e)^2$	π_{2A}	$\frac{1}{36b}(\alpha+2\delta)^2$	$\frac{1}{144}(-2\alpha+2\delta-5e)^2$
π_{1B}		$\frac{1}{144b}(-2\alpha+2\delta+7e)^2$	π_{2B}		$\frac{1}{144b}(-2\alpha+2\delta+7e)^2$
P_1	$\frac{2}{3}a+\frac{1}{3}c$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{3}\delta+\frac{1}{6}e$	P_2	$\frac{2}{3}a+\frac{1}{3}c-\frac{2}{3}\delta$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{3}\delta+\frac{1}{6}e$

Table 3: Results Scenario 1 vs Scenario 4

Regarding the cost asymmetry (in parallel with the analysis for scenario 3) we note that, on scenario 4 $\mathbf{D_A}$ produces more than $\mathbf{D_B}$ (on both periods) and $\mathbf{D_A}$ profits are higher than $\mathbf{D_B}$'s. Moreover the $\mathbf{D_A}$ production and profits, on both periods, are higher on scenario 4 than on scenario 1, if $\boldsymbol{\delta} < \frac{\mathbf{5}}{\mathbf{2}}\mathbf{e}$.

As in previous analysis, the total amount produced, **Q**, is superior on scenario 1, on both periods. The reduction on $\mathbf{D_B}$ production is not offset by the increase on the $\mathbf{D_A}$'s production.

Also, if $\boldsymbol{\delta} < \frac{\mathbf{1}}{\mathbf{2}}\mathbf{e}$, firm **M** sets higher prices on scenario 4. The monopolist charges a higher **r** on period 1, as well as happens on scenario 2, since he knows that there will be regulation on following period. However, that price is not as high as in scenario 2 because in this situation there are asymmetric costs among his clients and for not losing too much in the sales to the inefficient one, firm **M** slightly reduces his price.

Furthermore, on scenario 4, the final price charged to consumers is higher than on scenario 1, on both periods. Thus, when there are differences on companies' costs and **M** acts on a strategic way, the final consumers suffer a price increase.

With regard to monopolist profits, if $\boldsymbol{\beta} > \mathbf{2k} + \mathbf{4}\boldsymbol{\delta}^{\mathbf{2}}$ (for the first period) and $\boldsymbol{\beta} > \mathbf{2k} - \mathbf{4}\boldsymbol{\delta}^{\mathbf{2}}$ (on second period), **M** has higher profits on scenario 4. Also, the sum of profits of both periods is higher on scenario 4 than on scenario 1, if $\boldsymbol{\beta} > \mathbf{2k}$. Thus, if these conditions are satisfied, the monopolist benefit from asymmetric costs between his clients and has incentives on behave strategically.

4.4. Discussion

From the resolution of model, the presented results and the comparisons between the created scenarios we can conclude that the price cap regulation is an effective measure to reduce monopolist profits and protect the consumers when applied on an industry with the characteristics defined on section 4.1.

The action of price cap regulation is analyzed by the effects of the second period price restriction expressed by: $\mathbf{r_2} = \mathbf{r_1} - \boldsymbol{\delta}$. The parameter $\boldsymbol{\delta}$ symbolizes the minimum reduction on period's 2 price due to the effect of the inflation, efficiency gains and possible exogenous costs. From the model we conclude that all the second period variables are influenced by the parameter δ, reflecting the action of price cap regulation. That action is also visible when the only firm that works on production market, market where it is applied the price regulation, maximize their profits strategically. In that situation, the first period variables are also influenced by δ.

Moreover when it is studied the scenarios where there are cost asymmetry between distribution firms, all the variables are influenced by the constant **e.** That constant represents the difference among the production costs of the distribution companies. Hence, in a market with cost asymmetry the variables values mirror that difference.

With the application of the price cap regime, the production costs and final prices (**r** and **P**) suffer a reduction and the market quantities increase (from first to second period). Thus, distribution firms can produce more at a lower production cost (they consequently earned higher profits) and consumers benefit from extra quantities at a lower price.

However, as the price charged by production monopolist reduces, he faces a trade-off between to sell more at lower price or maximize his profits knowing that will be subject to regulation.

Therefore, when the monopolist has strategic behavior (scenarios 2 and 4) he earned the same profits on both periods in order to reduce the effect of the price cap regulation on his profits. When he maximize his profits in each period separately (scenarios 1 and 3), i.e., when he does not take in account that he will be subject to regulation on second period, his profits are higher on first period comparing with the second period.

Also, if the condition $\boldsymbol{\beta > 4k}$ defined in previous section is satisfied it is also satisfied that $\boldsymbol{\beta > 2k}$. Hence, it is assured that the production monopolist earns the higher profits when he behaves strategically and his clients have cost differences (scenario 4). On the opposite case, i.e., when he maximizes his profits with no concerns about the regulation that will suffer on next period and his clients have identical costs (scenario 1), he receives the lowest profits. Thus, price cap regulation is more effective on reducing producer profits when he does not behave strategically. Moreover the monopolist not only has incentives in behave strategically but also benefit when his clients have asymmetric costs.

Regarding the cost asymmetry, when the firms operating on distribution market have the same production costs they produce exactly the same and equally shared the profits, on both periods. If exist cost asymmetry it is the most efficient firm who produces more and earns higher profits.

Additionally, it may be profitable for firm **M** if his clients have differences on production costs. If the difference on production costs between distribution companies is too high, firm **M** earns higher profits. In that case, the monopolist is willing to reduce the price charged on first period for not lose the inefficient firms (what could happen as an outcome of the impossibility of those firms resist on market). Thus, the greater the cost asymmetry, the greater is the incentive of the monopolist to behave strategically.

With concern to the price charged by the monopolist firm we note that this price is higher when the monopolist strategically maximizes his profits and his clients have identical costs. On the contrary, that price is the lowest when the monopolist clients have asymmetric costs. Thus, the distribution companies also benefit with the existence of asymmetric costs, specially the most efficient one, since it has no additional production costs.

Furthermore, it is in the case when the distribution firms have identical costs and the monopolist working on production market does not behave strategically (scenario 1) that the final price is the lowest and the total amount available on the market is higher, on both periods. The consumers have more benefits on that case. On the contrary, when there is cost asymmetry and strategic behavior by the upstream monopolist (scenario 4) the total quantity available is the lowest and the final price charged to consumers is the biggest of all scenarios. Moreover, when the monopolist has a strategic maximization profits and assuming that his clients has identical costs (scenario 2) the final price paid by the consumers is higher. In these situations the consumers lose.

Finally, we can conclude that although the price cap regulation is an effective measure there is no scenario where all the economic agents benefit.

Chapter 5

Conclusion

Economic regulation is used when there are market failures which require the government intervention to increase the market competition, to reduce prices on essential goods or even to reduce profits higher than the normal ones. These excess profits can be the result of one of the market failures studied in economics: market power exercised by companies.

On tobacco market, the market power exercised by tobacco producers, on a global scale, is one of the failures. The “Big-Four” group of tobacco industry holds around 70% of world market share. In Portugal, one of the companies that belong to that group has a subsidiary in the country. That company is the higher tobacco company and one of the largest companies in Portugal.

The literature has intensely discussed the features of price cap regulation and tobacco market but has never related this type of regulation to tobacco market until 2010. Gilmore *et al.* (2010) were the first to suggest that the application of price cap regulation on tobacco market could raise government revenue and bring benefits to public health. The following work of Branston and Gilmore (2014) applied this idea to United Kingdom and using the profits range evidenced by some European transnational companies operating in more competitive markets the authors reach some interesting conclusions about tobacco market.

This dissertation arises following these previous works and contributes to understand the flexibility of price cap regulation and how such instrument could change tobacco market. Thus, the main goals of this dissertation were to study the economic effects of price cap regulation imposed to tobacco producers and to answer the following research questions: “Does price cap regulation reduce producer’s profits?” and “How price cap regulation affects the government revenue and consumer welfare?”

To achieve these objectives, we built a theoretical model inspired on the characteristics of Portuguese tobacco industry. That model sought to study the effects of price cap regulation on a market with the characteristics defined on Chapter 4. The model allows the understanding of what happens if the monopolist operating on production market has a strategic thinking, anticipating the effects of regulation. In addition, the model included the study of asymmetric costs between distribution companies, which makes one of the firms more efficient than the others.

From the analyses of the results we conclude that price cap regulation is an effective policy instrument since it reduces the price charged by producers to distribution companies, which is the immediate result of the price cap imposed to tobacco producers. Furthermore the final price is also reduced and the quantities produced are increased.

One of the conclusions which enable to answer the research question is that producer's profits are reduced by price cap regulation but only when the firm does not behave strategically. This is a very important conclusion, especially to regulators. It is expected that a large company quickly adopts a strategic behavior after the implementation of the price regulation. Thus, the regulator must take into account this conclusion.

Another important conclusion is that price cap regulation reduces the final price charged to consumers. It would be a good signal if tobacco was a good with no health consequences, which is not the case. Nevertheless and following the proposal of Gilmore *et al*. (2010), the final prices do not suffer any changes, in order to not encourage tobacco consumption (especially between the youth) and consequently bring benefits to public health. Therefore, the difference would be reestablished by tax increasing. So, the government revenue would rise by $\frac{2}{3}$ of the net effect of the inflation, expected efficiency gains and exogenous costs when the producer does not behave strategically and by $\frac{1}{3}$ of that effect when he strategically maximizes his profits. Thus, the tax revenue that can be collected by the government is higher when there is no strategic behavior.

On a final note, the consumer only benefit of larger quantities available on the market. One of the model's results is that after price cap regulation the prices are lower and the quantities are higher. However, if this measure is applied to tobacco market it must be ensured that final price is maintained (by applying the suggestion of Gilmore *et al*. (2010)). Therefore, the consumer welfare can be increased since they pay exactly the same price for more quantities.

The theoretical model presented can be applied to any market with similar features as those considered. Moreover, for future research it would be important to study the case of upstream competition and the situation where the firms have an informational advantage against the regulator (with respect to production costs or to the demand faced by firms, for instance). Finally, if price cap regulation is implemented it would be interesting to analyze, through simulations with real data, if the results obtained in the model occur.

Appendices

Appendix A - Results

	Results			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Period 1			
Q_1	$\frac{1}{3b}\alpha$	$\frac{1}{3b}(\alpha-\delta)$	$\frac{1}{6b}(2\alpha-e)$	$\frac{1}{6b}(2\alpha-2\delta-e)$
r_1	$\frac{1}{2}a+\frac{1}{2}c$	$\frac{1}{2}a+\frac{1}{2}c+\frac{1}{2}\delta$	$\frac{1}{2}a+\frac{1}{2}c-\frac{1}{4}e$	$\frac{1}{2}a+\frac{1}{2}c+\frac{1}{2}\delta-\frac{1}{4}e$
π_{M1}	$\frac{1}{6b}k$	$\frac{1}{3b}(k-\delta^2)$	$\frac{1}{24b}\beta$	$\frac{1}{12b}(\beta-4\delta^2)$
q_{1A}	$\frac{1}{6b}\alpha$	$\frac{1}{6b}(\alpha-\delta)$	$\frac{1}{12b}(2\alpha+5e)$	$\frac{1}{12b}(2\alpha-2\delta+5e)$
q_{1B}			$\frac{1}{12b}(2\alpha-7e)$	$\frac{1}{12b}(2\alpha-2\delta-7e)$
π_{1A}	$\frac{1}{36b}\alpha^2$	$\frac{1}{36}(-\alpha+\delta)^2$	$\frac{1}{144b}(2\alpha+5e)^2$	$\frac{1}{144b}(-2\alpha+2\delta-5e)^2$
π_{1B}			$\frac{1}{144b}(-2\alpha+7e)^2$	$\frac{1}{144b}(-2\alpha+2\delta+7e)^2$
P_1	$\frac{2}{3}a+\frac{1}{3}c$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{3}\delta$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{6}e$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{3}\delta+\frac{1}{6}e$
	Period 2			
Q_2	$\frac{1}{3b}(\alpha+2\delta)$	$\frac{1}{3b}(\alpha+\delta)$	$\frac{1}{6b}(2\alpha+4\delta-e)$	$\frac{1}{6b}(2\alpha+2\delta-e)$
r_2	$\frac{1}{2}a+\frac{1}{2}c-\delta$	$\frac{1}{2}a+\frac{1}{2}c-\frac{1}{2}\delta$	$\frac{1}{2}a+\frac{1}{2}c-\frac{1}{4}e-\delta$	$\frac{1}{2}a+\frac{1}{2}c-\frac{1}{2}\delta-\frac{1}{4}e$
π_{M2}	$\frac{1}{6b}(k-4\delta^2)$	$\frac{1}{3b}(k-\delta^2)$	$\frac{1}{24b}(\beta-16\delta^2)$	$\frac{1}{24b}(\beta-4\delta^2)$
q_{2A}	$\frac{1}{6b}(\alpha+2\delta)$	$\frac{1}{6b}(\alpha+\delta)$	$\frac{1}{12b}(2\alpha+4\delta+5e)$	$\frac{1}{12b}(2\alpha-2\delta+5e)$
q_{2B}			$\frac{1}{12b}(2\alpha+4\delta-7e)$	$\frac{1}{12b}(2\alpha-2\delta-7e)$
π_{2A}	$\frac{1}{36b}(\alpha+2\delta)^2$	$\frac{1}{36b}(\alpha+\delta)^2$	$\frac{1}{144b}(2\alpha+4\delta+5e)^2$	$\frac{1}{144}(-2\alpha+2\delta-5e)^2$
π_{2B}			$\frac{1}{144b}(2\alpha+4\delta-7e)^2$	$\frac{1}{144b}(-2\alpha+2\delta+7e)^2$
P_2	$\frac{2}{3}a+\frac{1}{3}c-\frac{2}{3}\delta$	$\frac{2}{3}a+\frac{1}{3}c-\frac{1}{3}\delta$	$\frac{2}{3}a+\frac{1}{3}c-\frac{2}{3}\delta+\frac{1}{6}e$	$\frac{2}{3}a+\frac{1}{3}c+\frac{1}{3}\delta+\frac{1}{6}e$

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